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CHAPTER 8

DETERMINATION OF ETHANOL CONTENT IN GASOLINE

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ABSTRACT

The National Agency of Petroleum, Natural Gas, and Biofuels (ANP) has established that the alcohol content standard for gasoline has increased from 27% to 30% by volume. Therefore, if the percentage obtained is lower or higher than the established standard, the gasoline will be considered an adulterated product. This was observed in the sample of the compound tested during the Organic Chemistry Laboratory course of the Bachelor's Degree in Chemistry at the Federal Institute of Education, Science, and Technology of Ceará (IFCE) - Ubajara Campus, a practice related to the year 2022. Therefore, this article aims to determine, through an experiment, the ethanol content present in a commercial gasoline sample, using volumetric titration. The method initially measured the alcohol content of commercial gasoline mixed with a saline solution (NaCl + distilled water). Subsequently, the alcohol content of the respective sample, mixed with distilled water, was measured. As a result, and according to the ANP's update on the alcohol content of gasoline, the data obtained demonstrated that the ethanol content in the laboratory-tested sample of the respective product was adulterated, as the values found were far from the percentage permitted by the ANP.

Keywords: Gasoline; Alcohol content; Adulteration.

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INTRODUCTION

The monitoring carried out by the National Agency of Petroleum, Natural Gas, and Biofuels (ANP) regarding the presence of ethanol content in gasoline is a factor of utmost importance in the composition of the product, as it has a direct economic impact, particularly concerning issues related to improving octane rating and engine performance, as well as an environmental impact by reducing pollutants in the environment. In this regard, Silvana (2013, p.12) argues that: "The lack or excess of alcohol in relation to the limits established by the ANP compromises the quality of the product that reaches Brazilian consumers. Thus, evaluating the composition of gasoline, verifying whether the alcohol content is adequate, is a very important measure."

Due to the increase in fuel adulteration, specifically gasoline, the ANP, through inspections, sets the alcohol content of this product at 30% by volume (National Agency of Petroleum, Natural Gas, and Biofuels, 2025). Based on this, it is understood that product quality is a crucial factor, given that gasoline can be adulterated with different organic solvents, which are primarily responsible for impacting both the economy and the environment.

The organic solvents used for gasoline adulteration generate various consequences, which may include economic benefits and environmental impacts; however, they can also cause disadvantages, such as increased fuel consumption, engine malfunction (Takeshita, 2006, p.1), among others.

Therefore, the present study seeks to determine the alcohol content in a sample of commercial gasoline, verifying whether it complies with the technical standards established by the ANP.

Accordingly, this article is structured as follows: (i) The first section presents the methodology followed, divided into three stages: sample collection, materials and reagents, and experimental procedure. (ii) The second section discusses the results obtained.

METHODOLOGY

This article is characterized as experimental in nature, aiming to analyze the alcohol content in a sample of commercial gasoline extracted from the stock solution used in a practical activity conducted during the Organic Chemistry Laboratory course of the Chemistry Licentiate Degree at the Federal Institute of Education, Science, and Technology of Ceará (IFCE), Ubajara Campus, in 2022. The purpose was to verify whether the ethanol levels found still comply with the 2025 legislation.

RESEARCH STAGES

The present work was developed in the following stages:

1st Stage: Sample Collection

For the laboratory practice, a significant amount of gasoline sample was collected from the stock solution, which was provided to the students of the Chemistry Licentiate Degree at IFCE, Ubajara *Campus*, during the Organic Chemistry Laboratory course in 2022. This amount was then placed in a graduated cylinder, which was later used for the corresponding experiment.

2nd Stage: Materials and Reagents

In this stage, the materials and reagents used for the experiment were prepared. Table 1 below presents the list.

Table 1 – Materials and reagents used in the determination of ethanol content in gasoline.

Materials	Reagents
Pasteur pipette	50 mL of distilled water
Volumetric flask (50 and/or 100 mL)	50 mL of gasoline sample
100 mL beaker	NaCl solution
Spatula	
100 mL graduated cylinder (with stopper)	
Semi-analytical balance	
Funnel	
Volumetric flask containing stock solution (gasoline)	
Wash bottle	

Source: Prepared by the author (2022).

3rd Stage: Experimental Procedure

For the execution of the practice, some steps were followed, which are presented in detail below.

In the first part of the experiment, the container with NaCl was taken to the semi-analytical balance, and 5 g of salt was weighed and placed in a beaker. After that, another beaker was used, 50 mL of distilled water was added, and it was gradually transferred into the container with the salt until a saline solution was formed.

With the saline solution prepared, the gasoline stock solution was taken, and an aliquot was transferred to a larger volumetric flask, which served as the base for extracting the necessary amounts for the preparation of the experiment. After that, 50 mL of the portion extracted from the initial gasoline solution was placed in a 100 mL graduated cylinder, and the prepared saline solution was added together, which were then stirred with the aid of a spatula. After that, the solution was left to rest for an interval of 10 minutes until the mixture reached equilibrium. Soon after, the alcohol content of the gasoline and saline solution mixture was calculated.

In a second step, following the same procedure as the first part of the practice, another 50 mL of gasoline was taken, placed in a 100 mL graduated cylinder, and 50 mL of distilled water was added. Subsequently, the container with the mixture was stirred with a spatula and left to rest for 10 minutes until the solution reached equilibrium. Later, the alcohol content contained in this mixture was also calculated.

After carrying out the experimental procedures, the differences in alcohol content in the gasoline were analyzed, referring to both the mixture of gasoline with the saline solution and the mixture of gasoline with distilled water.

RESULTS AND DISCUSSION

According to Brazilian legislation, the National Agency of Petroleum, Natural Gas, and Biofuels (ANP) establishes that the standard alcohol content in gasoline must be 30% by volume (National Agency of Petroleum, Natural Gas, and Biofuels, 2025). Therefore, if the percentage obtained is lower or higher than the established standard, the gasoline will be classified as an adulterated product, a detail that was analyzed in the sample of the compound tested in the laboratory practice.

Based on this, it is noted that in the first and second parts of the experiment, the alcohol contents found in the analyzed gasoline showed variations of 6% and 8% from the expected percentage, respectively, with the values found being 24% and 22%. These variations above or below the target value of 30% ethanol in gasoline occurred due to the influence of some factors.

Initially, it is pointed out that one of the contributing factors to the margin of error observed in the steps is related to the moment of reading the meniscus, since during the practice the amount in mL of gasoline may not have reached the meniscus mark, which significantly contributed to the final result obtained in the experiment.

A second interference concerns the possible adulteration of the product itself, which does not rule out other factors during the practice, such as the calibration of the semi-analytical balance, since the instrument showed a significant margin of error, which may have caused discrepancies in the expected results.

Thus, it is analyzed that if the instrument is not well calibrated, there will be considerable distortions in the results obtained throughout the experiment, that is, errors that originate from the beginning of the practice and consequently persist throughout the experiment.

A third interfering factor is related to the distiller used, as the equipment was not in proper working condition, given that it was not cleaned and had other maintenance issues. Therefore, it is observed that the distilled water used was not completely pure, as required for this part of the experiment.

The fourth aspect raised during the execution of the experiment concerns possible errors in measuring the concentrations of the substances used, as can be seen from the initial measurement of 5 g of NaCl on the semi-analytical balance. As a result, incorrect values were obtained compared to the expected results.

ANALYZING THE RESULTS

For a better understanding of the results generated, in items 3.2 and 3.3, the calculations related to the first and second parts of the experiment are presented, corresponding to (Gasoline + Saline Solution) and (Gasoline + Distilled Water), respectively.

GASOLINE + SALINE SOLUTION

Below is the calculation of the first part for determining the alcohol content in gasoline through its mixture with the saline solution.

A) 12 mL — 50 mL of initial gasoline

X% — 100 %

$$50\ mL.\ X\% = 100\ \%.\ 12\ mL$$

$$50\ mL.\ X\% = 1200\ mL.\ \%$$

$$X\% = \frac{1200\ mL.\%}{50\ mL}$$

X= 24% Ethanol in gasoline

For this, the variation in the volume of the saline solution with the initial amount of gasoline was used. These were $\Delta V = 12$ mL and $Vi = 50$ mL, respectively.

From the result obtained, it is observed that the alcohol dissociated from the gasoline and migrated to the aqueous solution. This occurred because ethanol has a polar part and a nonpolar part; its nonpolar part is attracted to the gasoline molecules, which are also nonpolar, and its polar part, which contains the OH group, is attracted to water molecules, which are polar, forming hydrogen bonds that are much stronger than the bonds with nonpolar molecules.

Table 2 below presents the differences between the initial and final volumes of the respective solution.

Table – 2. Volume differences

Initial volume (mL)	Final volume (mL)	Ethanol content (measured in practice) %
Gasoline 50 mL	38 mL	24%
Saline Solution 50 mL	62 mL	

Source: Prepared by the author (2022).

As observed, the analyzed gasoline does not fall within the limits established by the National Agency of Petroleum, Natural Gas, and Biofuels (ANP), showing a significant discrepancy of 6% from the expected value set by the Agency.

According to the rules established by the ANP, the margin of error accepted in the percentages found in gasoline analyses can be either above or below, with a discrepancy of 1%. That is, in the first stage, the result obtained was 24% alcohol content, which clearly shows that the analyzed gasoline does not comply with the Agency's standards and is therefore classified as an adulterated product.

O quadro 3 abaixo apresenta o teor de etanol teórico, ou seja, permitido pela ANP e o percentual experimental obtido.

Table – 3. Discrepancy between theoretical ethanol content and the value obtained in practice

Solution	Updated ethanol content (theoretical) allowed by ANP	Ethanol content (measured in practice) %
A) Gasoline + Distilled Water + NaCl	30%	24%

Source: Prepared by the author (2025).

GASOLINE + DISTILLED WATER

In the second stage of the practice, it was expected that the mixture of gasoline with distilled water would have an ethanol content of 30% by volume; however, the value obtained was 22% by volume. Thus, this solution showed a significant reduction of 2% by volume compared to the solution in the first stage, which showed 24% alcohol.

Below is the calculation related to the mixture of gasoline with distilled water.

B) 11 mL — 50 mL of initial gasoline

X% — 100

$$50\ mL\ X\% = 100\ \%.\ 11\ mL$$

$$50\ mL.\ X\% = 1100\ mL.\%$$

$$X\% = \frac{1100\ mL.\%}{50\ mL}$$

X= 22% Ethanol in gasoline

Following the same calculation procedure as in the first part (gasoline with saline solution), in this second part, referring to the mixture of gasoline with distilled water, the variation in the volume of distilled water with the initial amount of gasoline was used. These were $\Delta V = 11$ mL and $V = 50$ mL, respectively.

Thus, it is analyzed that for this second moment of the experiment, in addition to showing a reduction of 2% by volume compared to the value found in the first stage, it also differs from the value determined by the current legislation. Table 4 below shows the differences between the initial and final volumes of this solution.

Table – 4. Volume differences

Initial volume (mL)	Final volume (mL)	Ethanol content (measured in practice) %
Gasoline 50 mL	37 mL	22%
Distilled Water 50 mL	61 mL	

Source: Prepared by the author (2022).

The percentage result identified for the above solution reinforces the possibility of adulteration of the analyzed gasoline sample, since the ethanol result does not comply with the standards established by the National Agency of Petroleum, Natural Gas, and Biofuels (ANP). Likewise, possible errors in laboratory execution cannot be ruled out, such as the purity of the distilled water used in the practice, as well as other errors already mentioned in this work.

Below is Table 5, which shows the discrepancy between the ethanol content measured experimentally and the content allowed by the current regulation for the proper use of the product.

Table – 5. Discrepancy between theoretical ethanol content and the value obtained in practice

Solution	Updated ethanol content (theoretical) allowed by ANP	Ethanol content (measured in practice) %
B) Gasoline + Distilled Water	30%	22%

Source: Prepared by the author (2025).

CONCLUSION

The present work sought, through a laboratory experiment, to measure the ethanol content present in gasoline. For this purpose, the experiment proved to be an important tool to verify whether the alcohol content in the gasoline sample used in this practice was in compliance with the technical standards established by the National Agency of Petroleum, Natural Gas, and Biofuels (ANP).

Thus, even though the experiment presented some minor laboratory interferences during the practice, the experiment followed the established protocols. Therefore, it is concluded that, according to the ANP update, the commercial gasoline used in this specific practice is adulterated, bringing several consequences not only economically but also environmentally.

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